Optical Communication Demonstration and High-Rate Link Facility

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Abstract

Motivated by demands for faster, better, cheaper spacecraft, NASA has been developing optical communication for deep-space applications to reduce the mass, volume, and power consumption of spacecraft communications systems compared to radio-frequency communication technology. Initial deep-space optical communication links are expected to pass through the atmosphere which dramatically impacts the temporal and transverse nature of the communication beam. It is critical that these effects be well understood. The purpose of the Optical Communication Demonstration and High-Rate Link Facility project, to be deployed on an EXPRESS Pallet to the nadir-looking S3 truss site of the International Space Station by flight UF-4 as part of the Engineering Research and Technology Development program, is to gather extensive long-term optical channel statistics as a function of such parameters as solar angle, zenith angle, and weather conditions. Studied channel statistics will include the sensitivity of fade rate and fade depth to mispoint and the performance of the acquisition and tracking system under the combined effect of atmospheric scintillation and platform vibration. In addition to collecting link statistics, the demonstration will test components of the NASA deep-space optical communication technology set such as the fast-steering mirror and focal plane array as well as the NASA-patented optical communication architecture.

The approach by which the project will achieve its purpose is to construct a flight-qualified optical transmitter based on the NASA-patented architecture of the laboratory-proved Optical Communication Demonstrator. The flight unit will utilize new fast-steering mirror technology to compensate for platform vibrations as well as a commercial off-the-shelf multi-GHz 1550-nm fiber laser transmitter and a correspondingly high-speed detector at the ground receiving station. This approach takes advantage of not only NASA-developed technology but also of the large investment made by the fiber communication industry in fiber and semiconductor laser technology as well as high-speed, integrated detectors.

The optical communication link is established using the beacon-laser method. The ground station, a 1-m-class telescope called the Optical Communication Telescope Laboratory slated to be completed in January 2000 at the Jet Propulsion Laboratory's Table Mountain Facility near Wrightwood, California, will transmit a beacon laser to the flight terminal. The flight terminal will image the beacon laser onto a focal plane array and utilize the image as a reference by which to point the downlink beam. Motion of the flight terminal appears as motion of the beacon image and is detected and subsequently compensated by a downlink beam pointing control loop. The principal mode of operation

will be to downlink a Gbps-class pseudorandom bit sequence to measure the bit-error-rate.

Results of the demonstration will include a detailed comparison of the measured optical channel link statistics to the predictions of optical communication models found in the literature. These results will be utilized to improve the ability to predict the performance of deep-space optical communication links. Although optical communication is being applied to commercial satellite ventures for satellite-to-satellite communications, little work has been done on the satellite-to-ground link. This project will explore this significant area of research as it applies to the needs of NASA for deep-space optical communication. In addition, the high-rate downlink capability will be made available to researchers on neighboring EXPRESS Pallet Adapters for high-rate downlink via a wireless LAN structure at rates likely exceeding 100 Mbps.